# Recent Developments in Real-time Environmental Monitoring

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## Introduction

Water monitoring sensor technology continues to evolve. In years past, most sensors required frequent maintenance and calibration. It was difficult to leave sensors in the field collecting and reporting the water quality data.

Recent advances have made it possible to deploy monitoring systems for weeks and even months without maintenance or calibration. With more robust systems, comes higher quality data and labor savings associated with field maintenance and calibration. Data transmission via radio, cellular and phone telemetry provides a real-time picture of the water quality. Automatic report generation and internet posting of data can provide water information to a broader audience

## Objective

Biofouling, debris, sediment, contaminates, pollution, … are all reasons for disappointment in long-term water monitoring. Instrument deployments that were expected to collect data for weeks only produce a few days of quality data. This story has been told many times over the past few decades.

## Approach

Recent technology advances have extended deployments to weeks. Data quality has improved resulting in better understanding of ecosystems and reduced labor costs associated with maintaining and calibrating water-monitoring systems.

There are 2 important aspects to data quality:

- Sensor performance
- Quality assurance

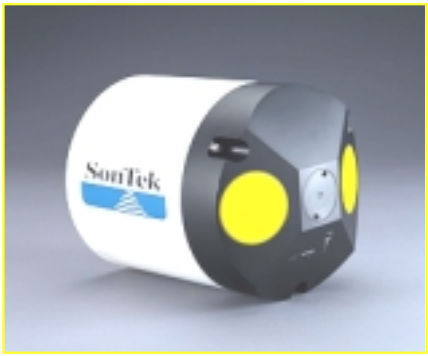
Manufacturers are developing technology to improve the performance of sensors. Users are creating and implementing quality assurance standard, which include frequent site visits. Affordable wireless communication and computer software provides early warning and allows for action before data quality is compromised.

## Technology

### Water Quality – YSI

- The YSI Rapid Pulse Dissolved Oxygen System is a new and patented technology. It provides weeks of quality data without the need for maintenance or calibration. The sensor does not require stirring and works well in the presence of biofouling.
- YSI is the only environmental instrument company to make it's own thermistors. The sensors are FDA approved and NASA qualified. YSI manufactures more than 500,000 thermistors per year. There are YSI thermistors on the ocean floor and on Mars.
- YSI supplies a polymer coated, stainless steel strain gauge for water level measurement. It is factory calibrated and characterized. The +/- 0.01 ft accuracy is good for the entire temperature range.
- The YSI turbidity and chlorophyll sensors are quickly becoming the industry standard for optical measurements. An innovative fiber optic design coupled with a built in cleaning mechanism provides weeks of reliable, quality data.

### Water Flow / Velocity - Sontek




- Real-time river discharge measurements with Acoustic Doppler technology.
- Streamgauging (discharge, velocity, water-level) with 2D and 3D Acoustic Doppler technology. Sontek provides both range integrated and point velocity systems.
- The Argonaut-SL can quickly and easily be mounted on one side of a stream or channel. There is no need to run cables across the channel. A third beam can be added for stage measurement.
- The Argonaut-XR provides an extended range. It has a SDI-12 interface, auto-tide capability and an optional wave spectrum package.
- For point measurements, the Sontek ADV uses 3-axis technology. It has 1% accuracy and can measure velocities < 0.04 inches / sec. It works in water as shallow as 1 inch.

## Weather – Vaisala

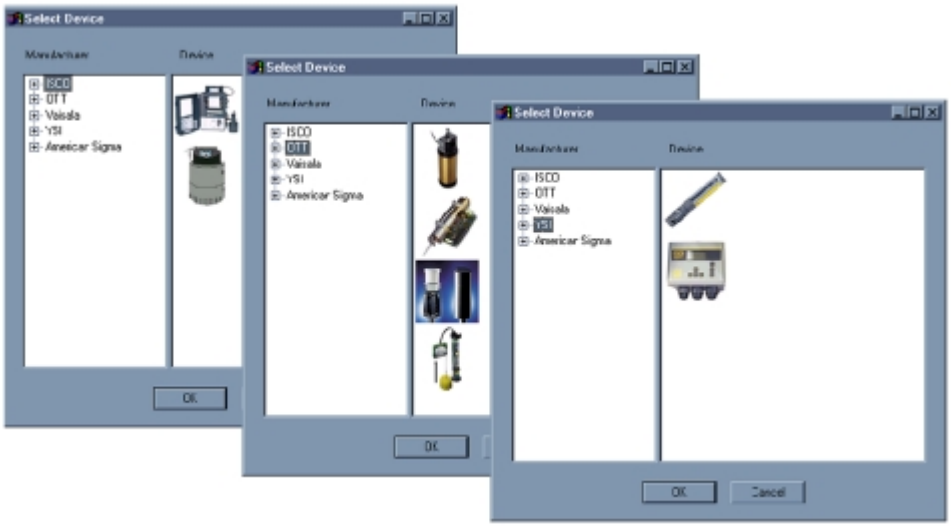
- A worldwide supplier of meteorological equipment.
- Vaisala designs and manufacturers most of the sensors. Other meteorological systems companies purchase a lot of the sensors.
- US Air Force has standardized on the MAWs 201 for TacMet. These units are deployed worldwide in times of crisis.
- The SIVAM project has 65 units deployed in the Amazon River jungles.
- The tripod withstands 70 mph winds.
- The unit has very low power consumption.
- Quick deployable. Everything is plug and play. 15-minute setup was a requirement for TacMet.

## Water Level - OTT Hydrometry

- 126-year-old company
- Leading supplier of hydrological equipment in Europe and growing fast in the US.
- Very innovative design features
  - Infrared communications
  - Integral displays
  - Motion switches
- Radar level sensor provides bridge mount and +/-0.03 ft accuracy to 100 ft.
- The shaft encoder is simple to setup, easy to install and can ------log data for 1 year with a single c-size battery.
- The bubbler level logger with integral micro-compressor fits in 2 inch well pipes and can be deployed for 1 year on 3 c-size batteries.

## Wireless Communication / Software - NexSens

- Collecting, processing and archiving environmental data is time consuming and expensive.
- NexSens makes it simple and affordable.
- NexSens ***i*Chart** software is the first 'Cross-Platform' (works with monitoring equipment from various suppliers) software package available.
- The device library continues to grow. It now supports sensors and systems from YSI, ISCO, Am Sigma, Vaisala, OTT and ATI. Under development are drivers for Onset, Campbell, Sutron, Handar and Sontek.
- Build a small or large network of monitoring instruments.
    - Select the instrument(s) of choice
    - Select the communication method
    - Start collecting data.
- Communication methods include:
    - Direct cable connect
    - Addressable RS485 for long cable and multidrop networks.
    - Spread spectrum radio
    - Telephone modem
    - Cellular modem
- Data is stored in an encrypted database.
- Data can be exported to spreadsheets and other databases.
- Reports are automatically generated by a simple data query and sent to the printer, email or posted to the internet.
- The software and communication hardware is designed to be installed by the end user and does not require expensive systems integrators.




***i*Chart** device library

# FONDRIEST environmental

- Advanced environmental monitoring technology from around the world.

- Representing...
  - YSI.....*Water Quality*
  - Vaisala.....*Weather*
  - Sontek.....*Flow, Velocity*
  - OTT.....*Water Level*
  - NexSens.....*Wireless communication, software*

# Overview

- Sensor Performance + Quality Assurance = Data Quality
- Environmental professionals rely on manufacturers to provide high performing sensors. There have been many advances in the past few years.
- Quality assurance can be improved with real-time communication.
- Data Quality ➔ Better understanding of the ecosystem
  Reduced labor costs.

# Water Quality - YSI

- YSI
  - Yellow Springs, Ohio
  - A leader in water quality measurements
  - 52 years old

- First dissolved oxygen sensor
- 2 recent patents on dissolved oxygen
- Innovative optical sensor designs
- Sensors are designed for long term deployment

# YSI Parameters

**Dissolved Oxygen**
% Saturation
Conductivity
Specific Conductance
Salinity
Resistivity
Temperature
pH
ORP

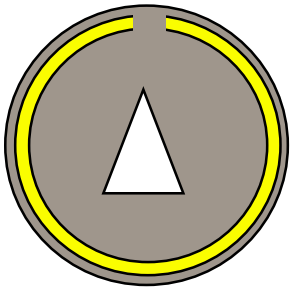
Depth
**Level**
Flow
Total Volume
Ammonium
Ammonia
Nitrate
Chloride
**Turbidity**
**Chlorophyll**

# Dissolved Oxygen

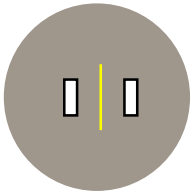
- YSI manufactures 3 types
  - Galvanic
  - Steady State - Polarographic
  - Pulsed - Polarographic

- YSI Patented -- No Stirring, fouling tolerant
  - Rapid Pulse
  - MEA

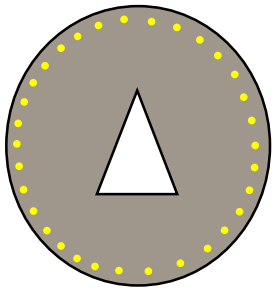
# Dissolved Oxygen



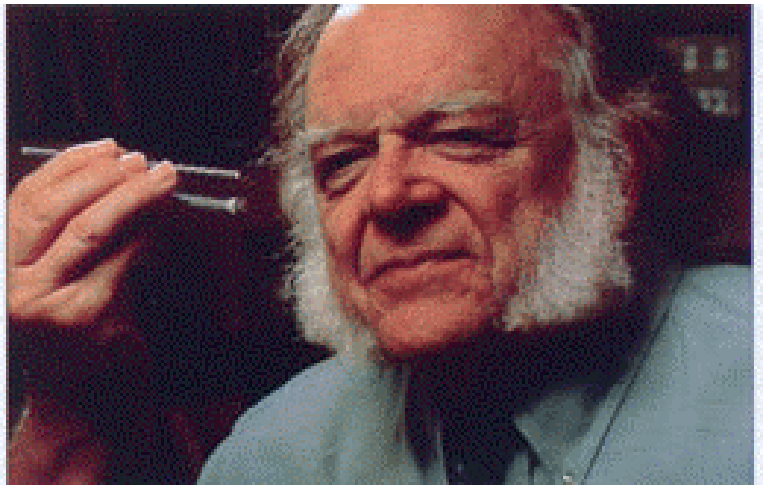
Traditional



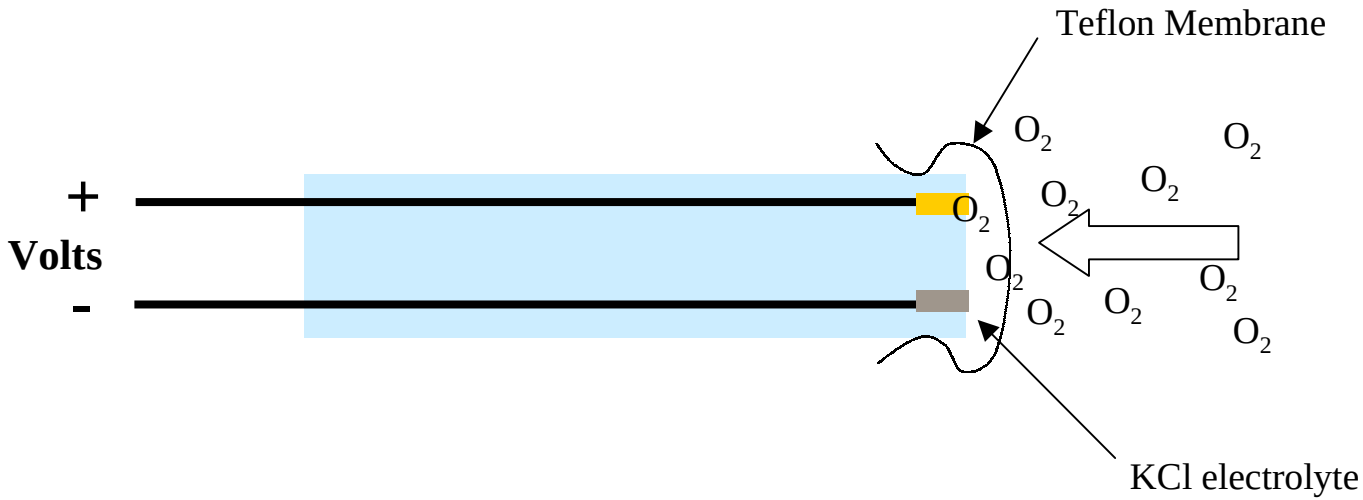
Rapid Pulse

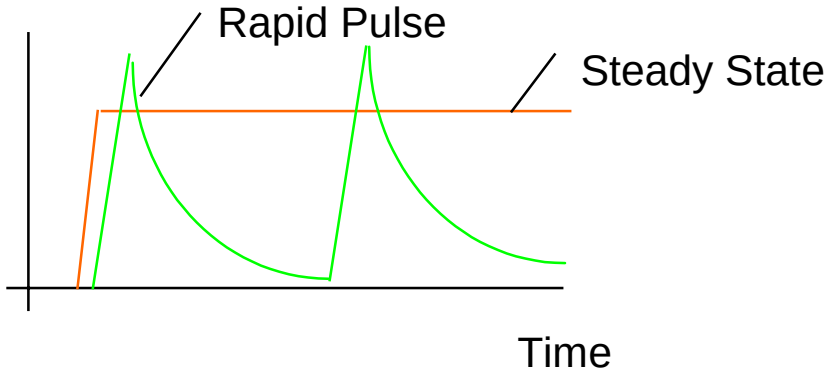


MEA



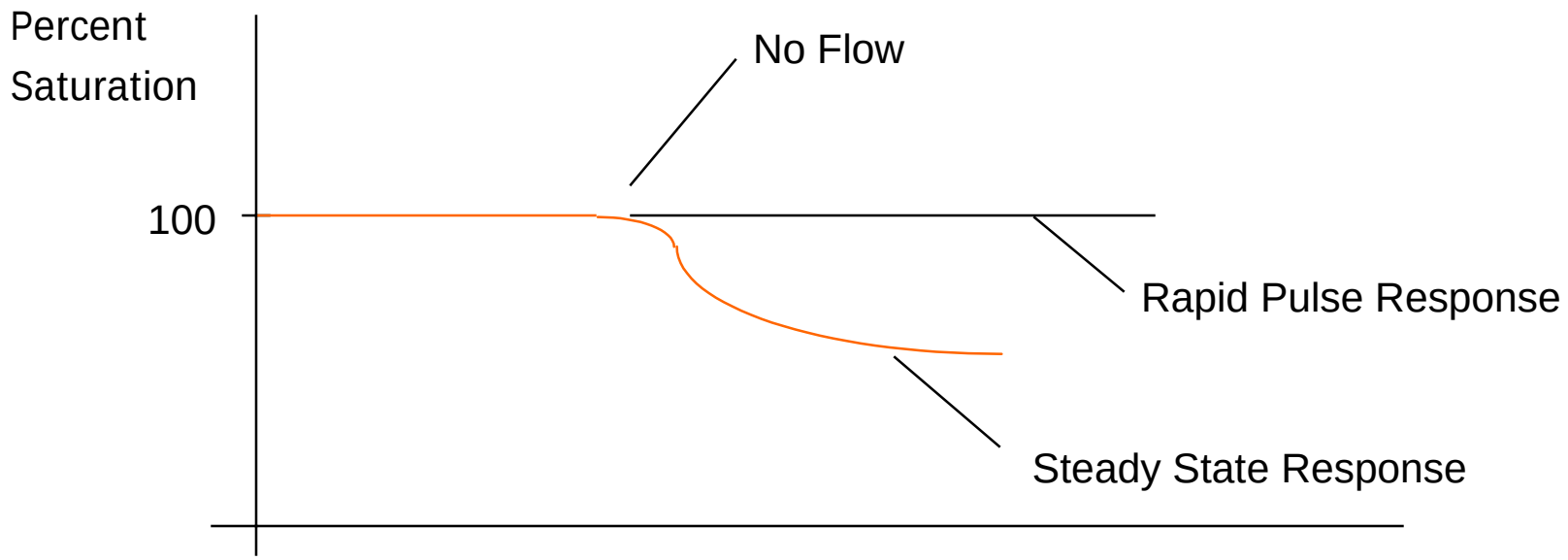
# Sensor function



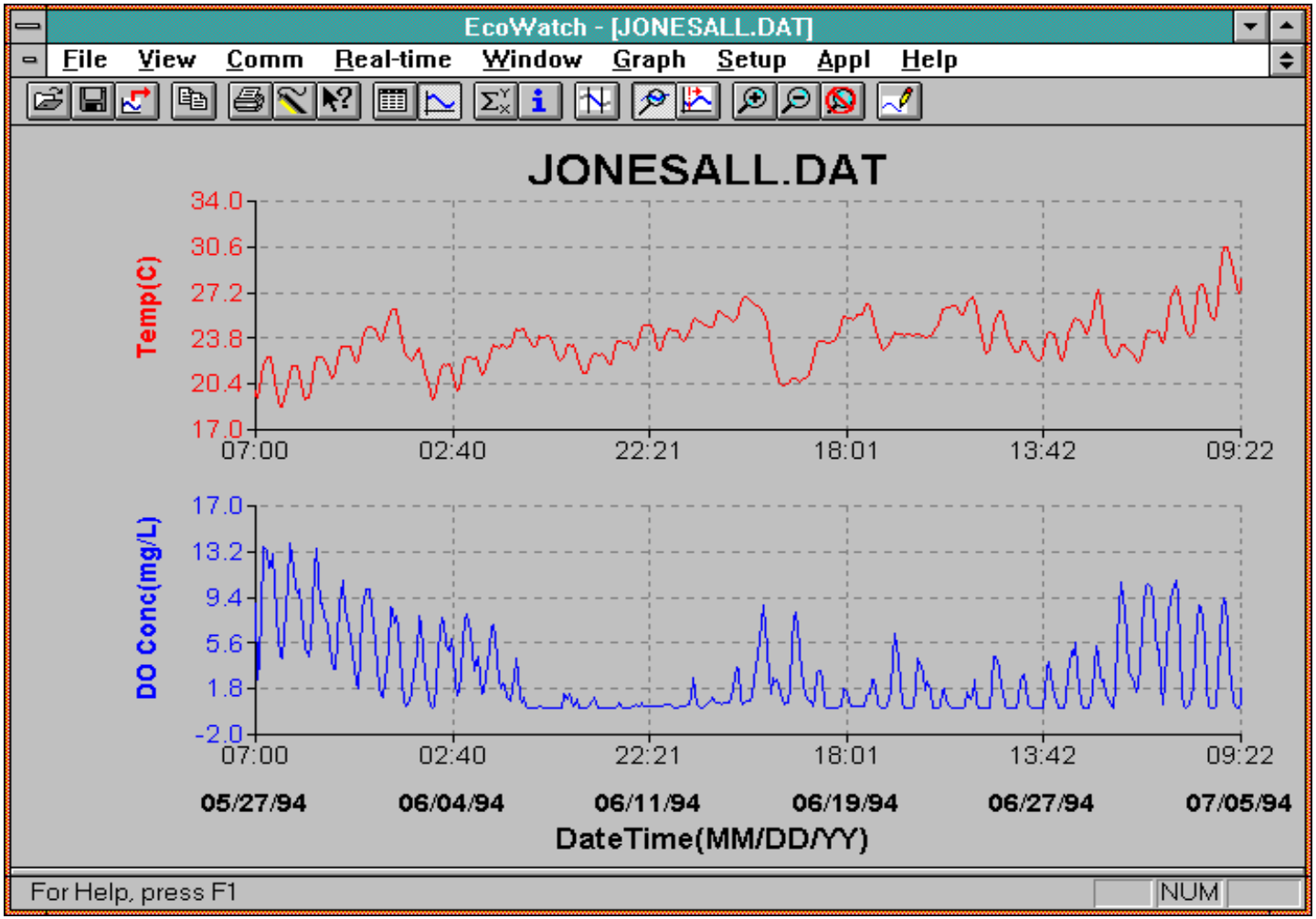

- Steady state sensors have large diffusion rates and require stirring or are slow responding. They are less tolerant to biofouling.
- Rapid Pulse sensors do not require stirring and are more tolerant to biofouling.

# Stirring Dependence



# Biofouling

# Sensor Performance




**6 weeks**

Pre deployment DO reading in air = 97.8%

Post deployment DO reading in air = 96.7%

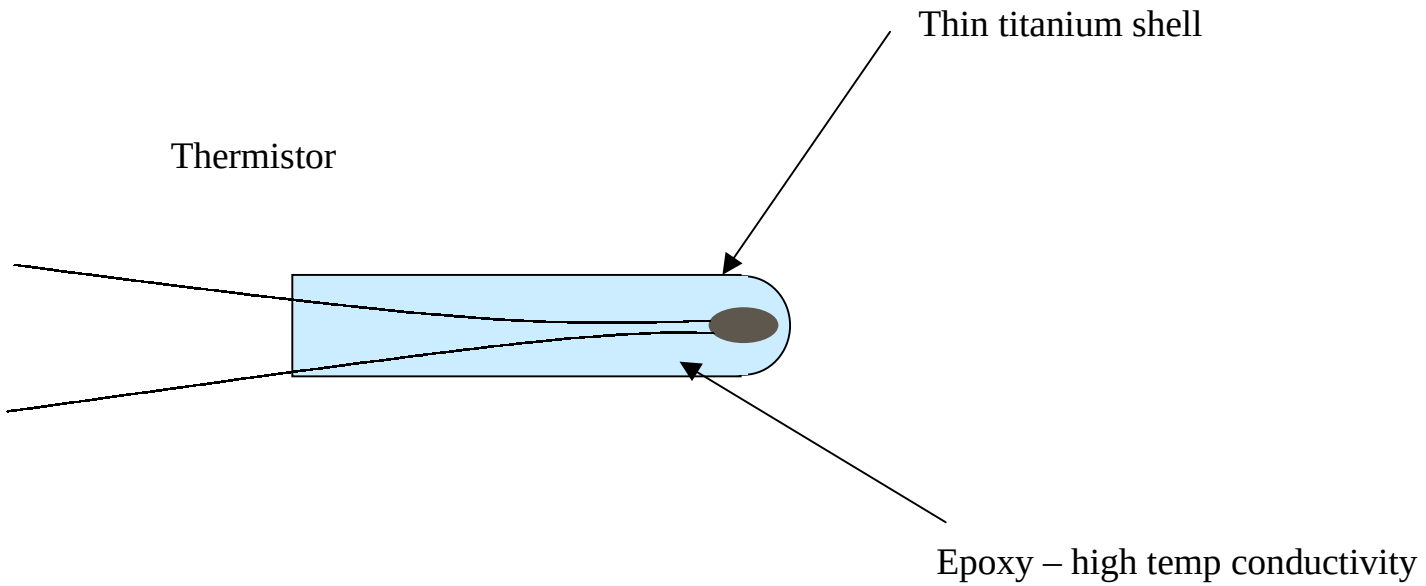
# Temperature

- YSI is the only environmental monitoring company that also manufacture temperature sensors.
- FDA approved and NASA qualified.
- Thermistors on Mars
- Ship 500,000 plus thermistors per year.

# Sensor function

Temperature Sensor – Thermistor

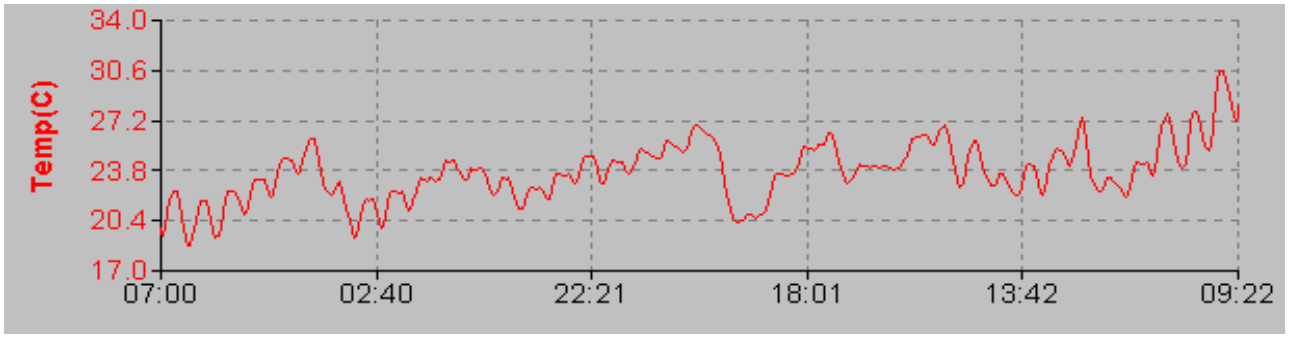
- Resistance changes with temperature
- Sensor design optimized for stability and fast response



# Sensor Performance

**YSI temperature element**

- **Years of service**
- **Highly stable**
- **Resists corrosion**

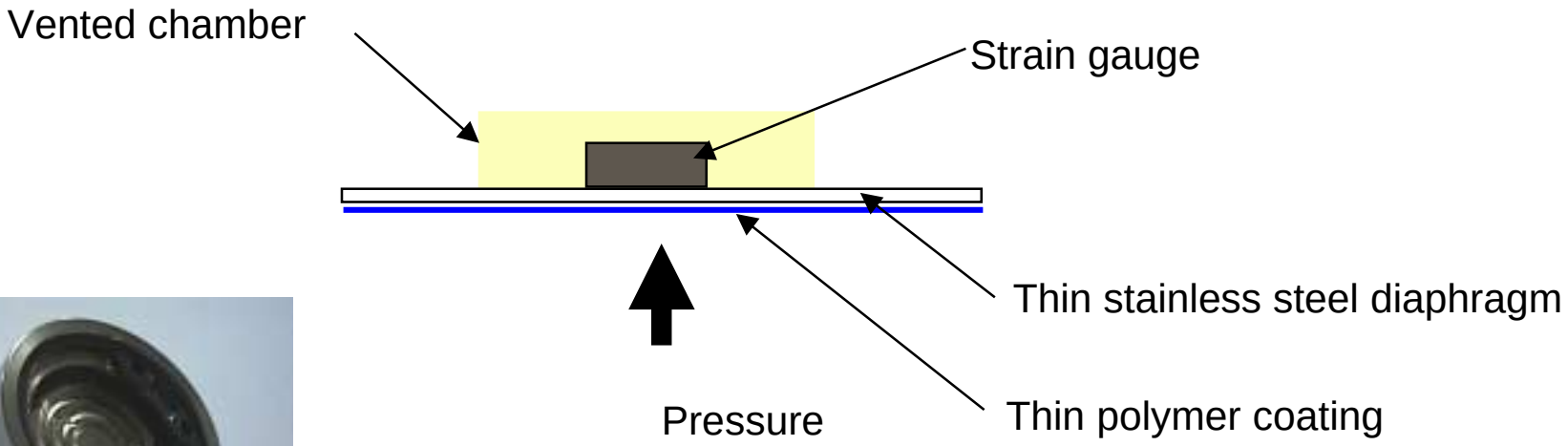


# Water level

- YSI uses a polymer coated, stainless steel diaphragm strain gauge
- Polymer coat provides years of service in highly corrosive environment.
- Software algorithms to compensate for
  - Density – varying with temperature and salinity
  - Gravitational constant
  - Air / water interface
- Accuracy = +/- 0.01 ft  (0 to 30 ft)

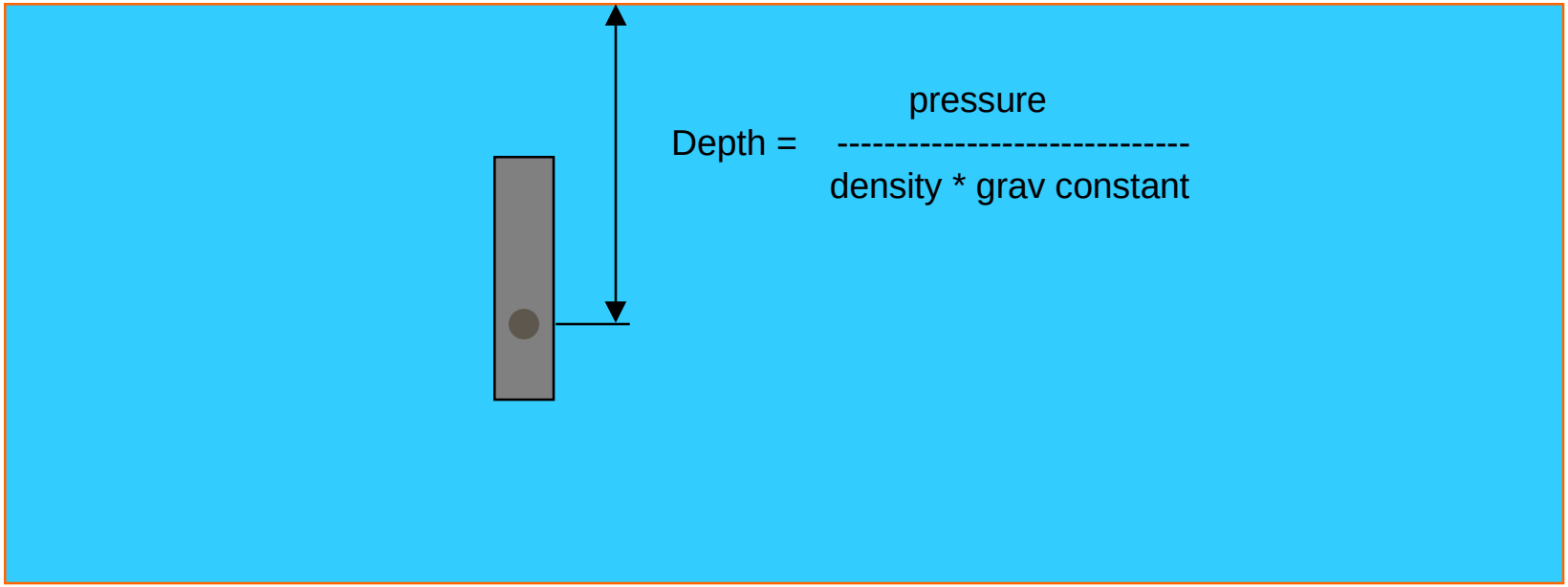
# Sensor function

**Vented Pressure Sensor**

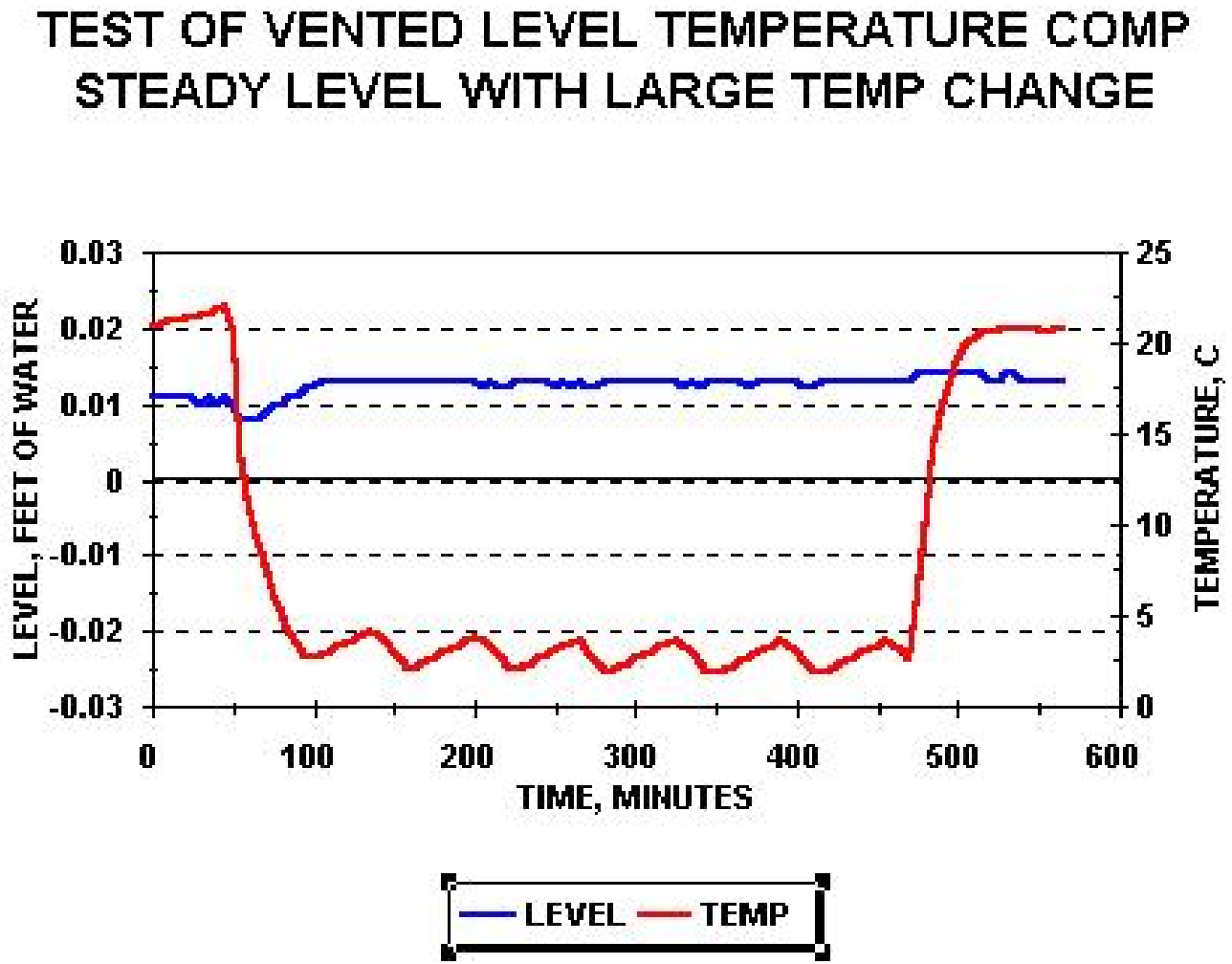


# Calculating Level from Pressure

- Pressure = (density) x (grav constant) x (depth)



# Sensor Performance



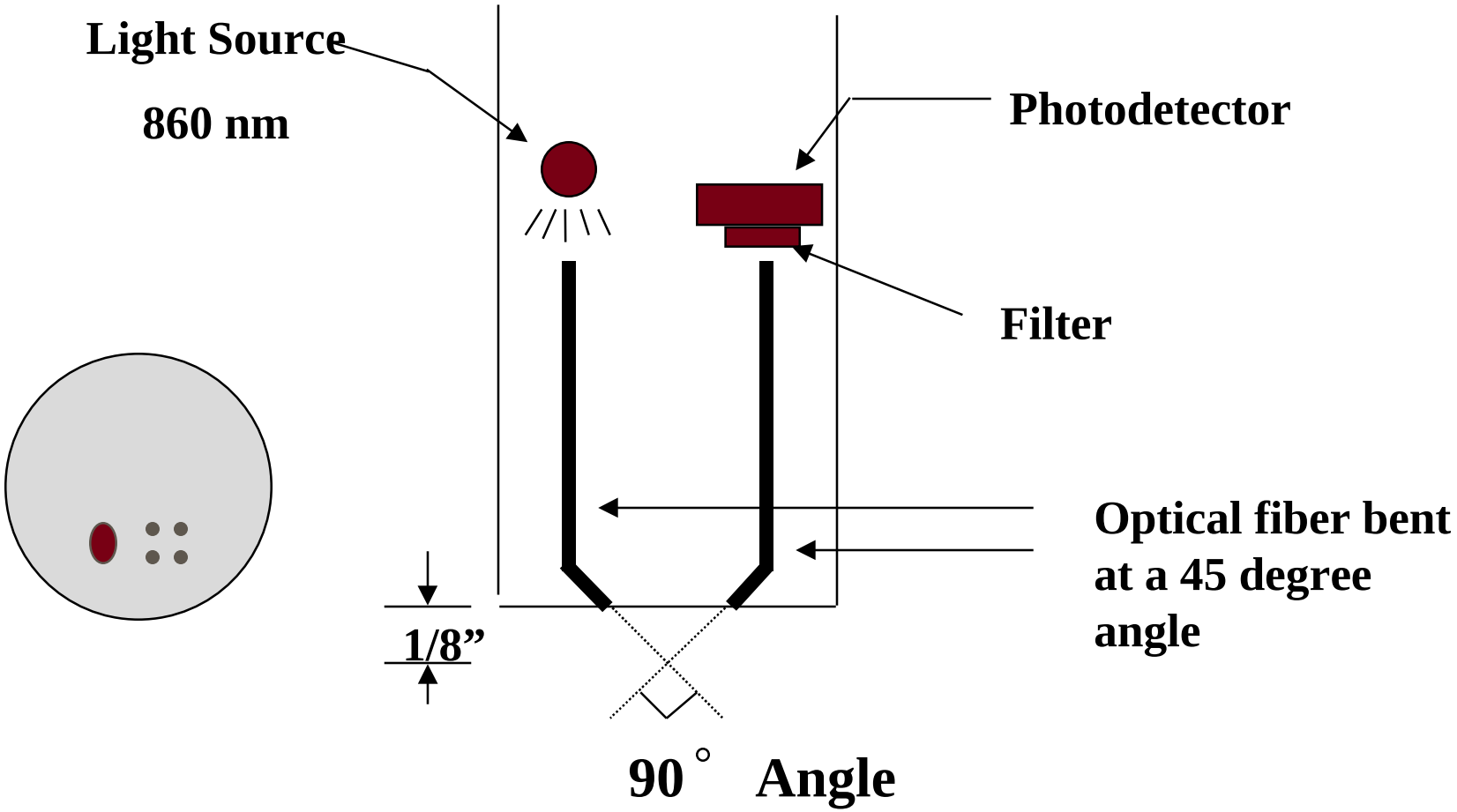
# Optical Sensors

- Turbidity
- Chlorophyll

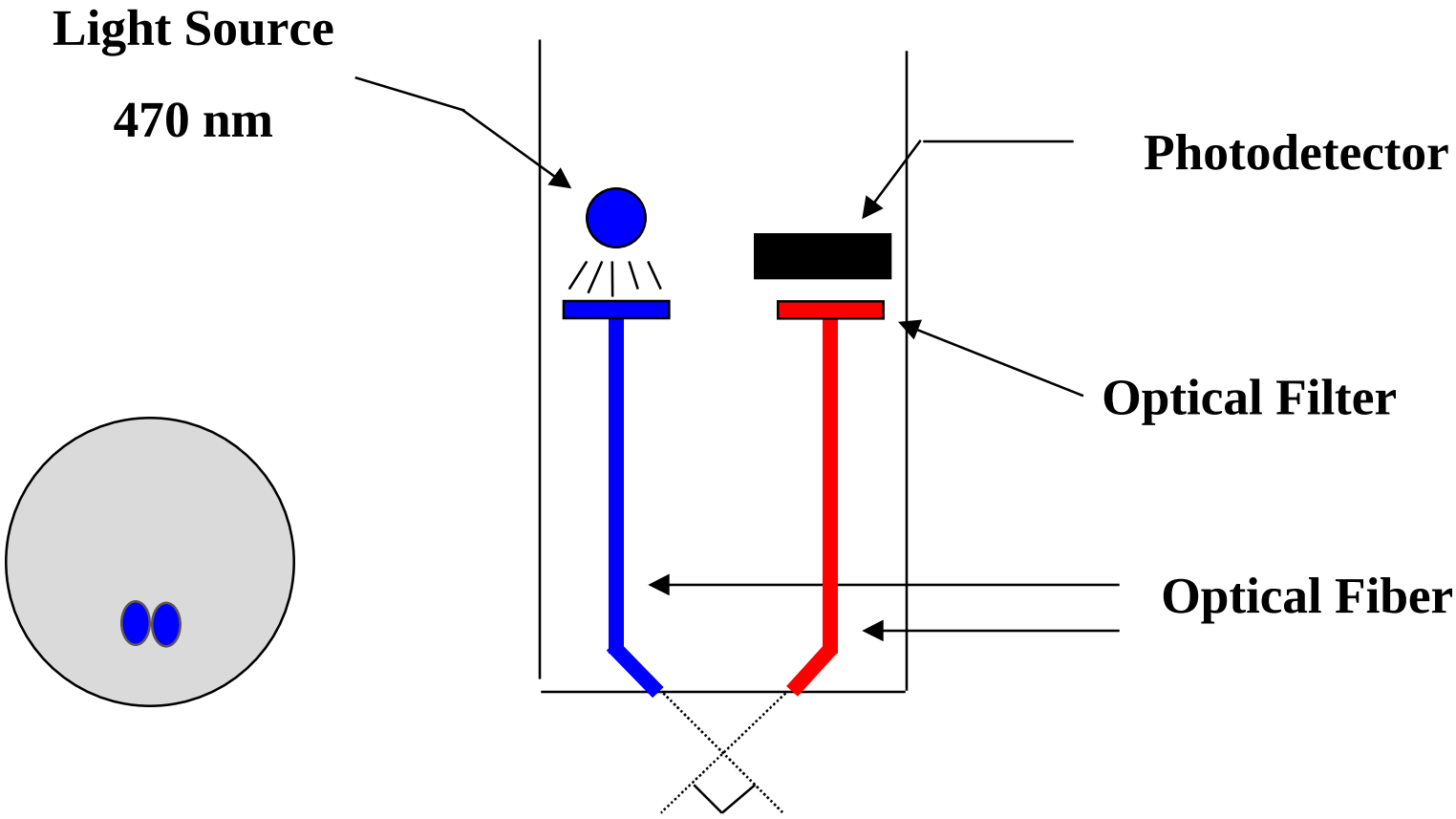
# Turbidity

- ISO 7027
- Fiber Optic Sensor
- No ambient light effects
- DCP and long term monitoring applications
- Self cleaning - long deployments

# Sensor Function - Turbidity



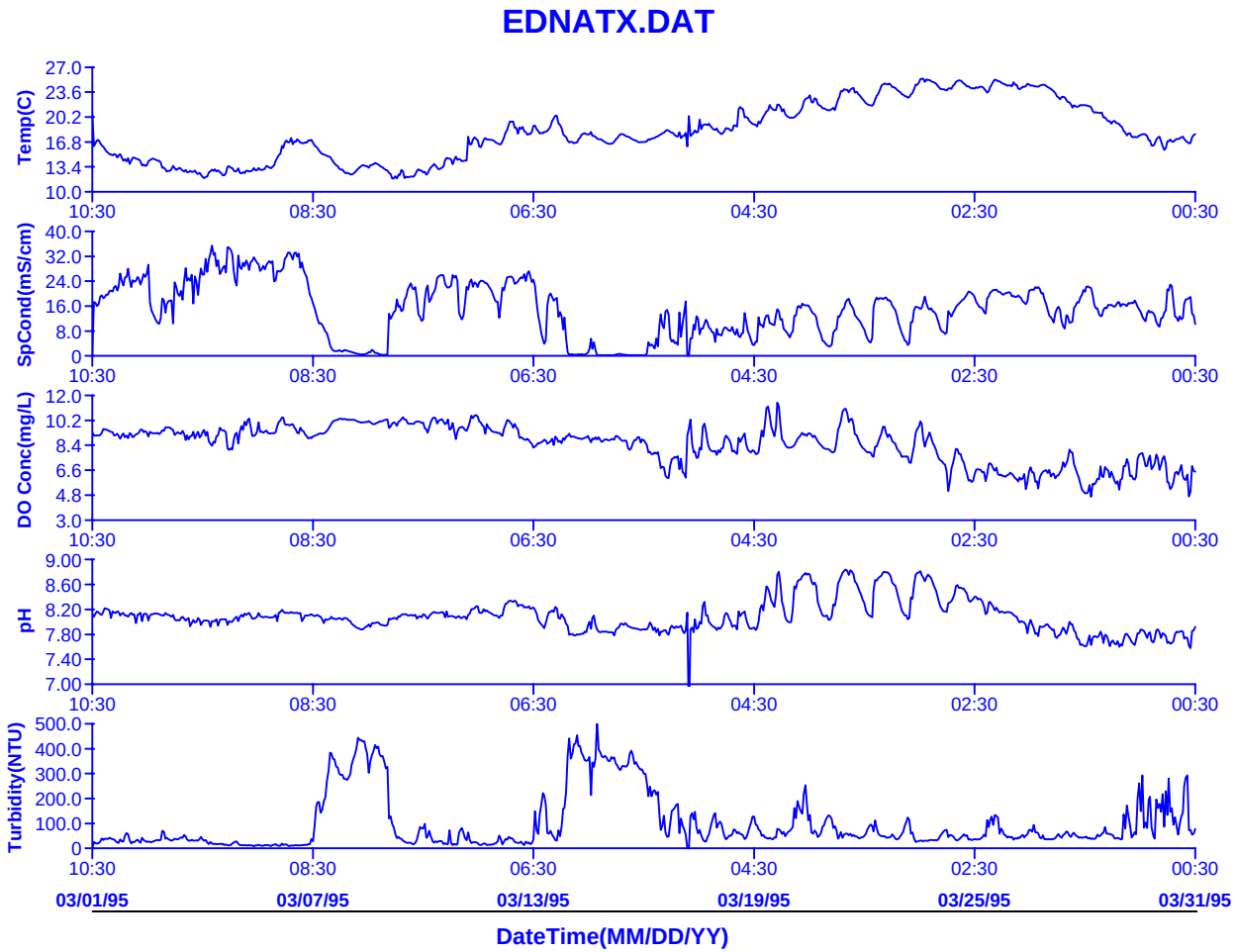
# Sensor Function - Chlorophyll



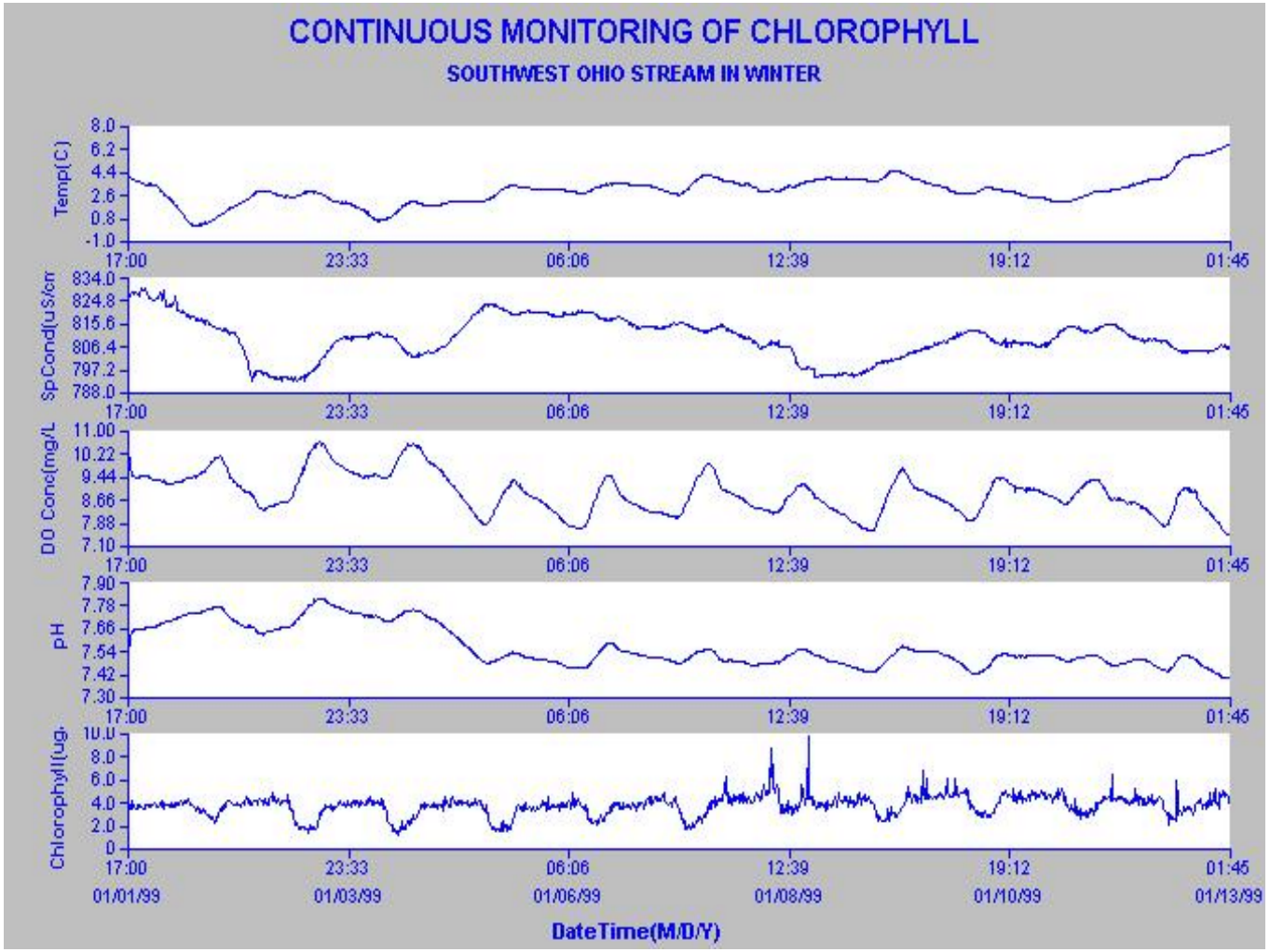
# YSI Optical Sensors

Self cleaning wiper prevents fouling on optical face

# Sensor Performance - Turbidity



# Sensor Performance - Chlorophyll



# YSI Customers at Work

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# Weather - Vaisala

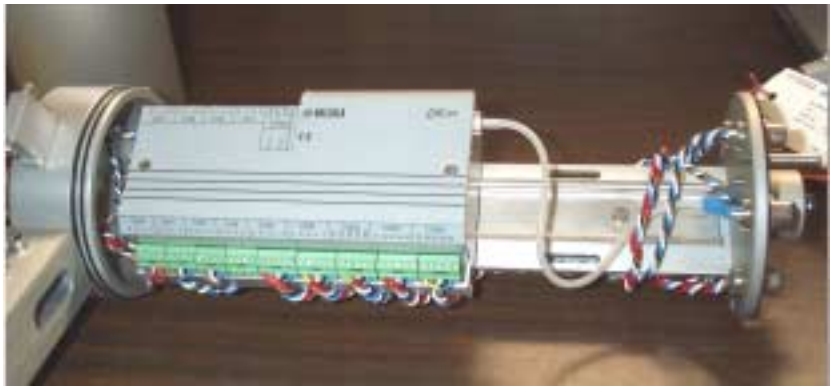
- Located in Helsinki, Finland
- Worldwide supplier of meteorological equipment
- U S Air Force has standardized on the Vaisala systems
- Recently purchased Handar (DCP)
- Smart weather station –
  - MAWS 101 for fixed site
  - MAWS 201 for portable

# Weather Station

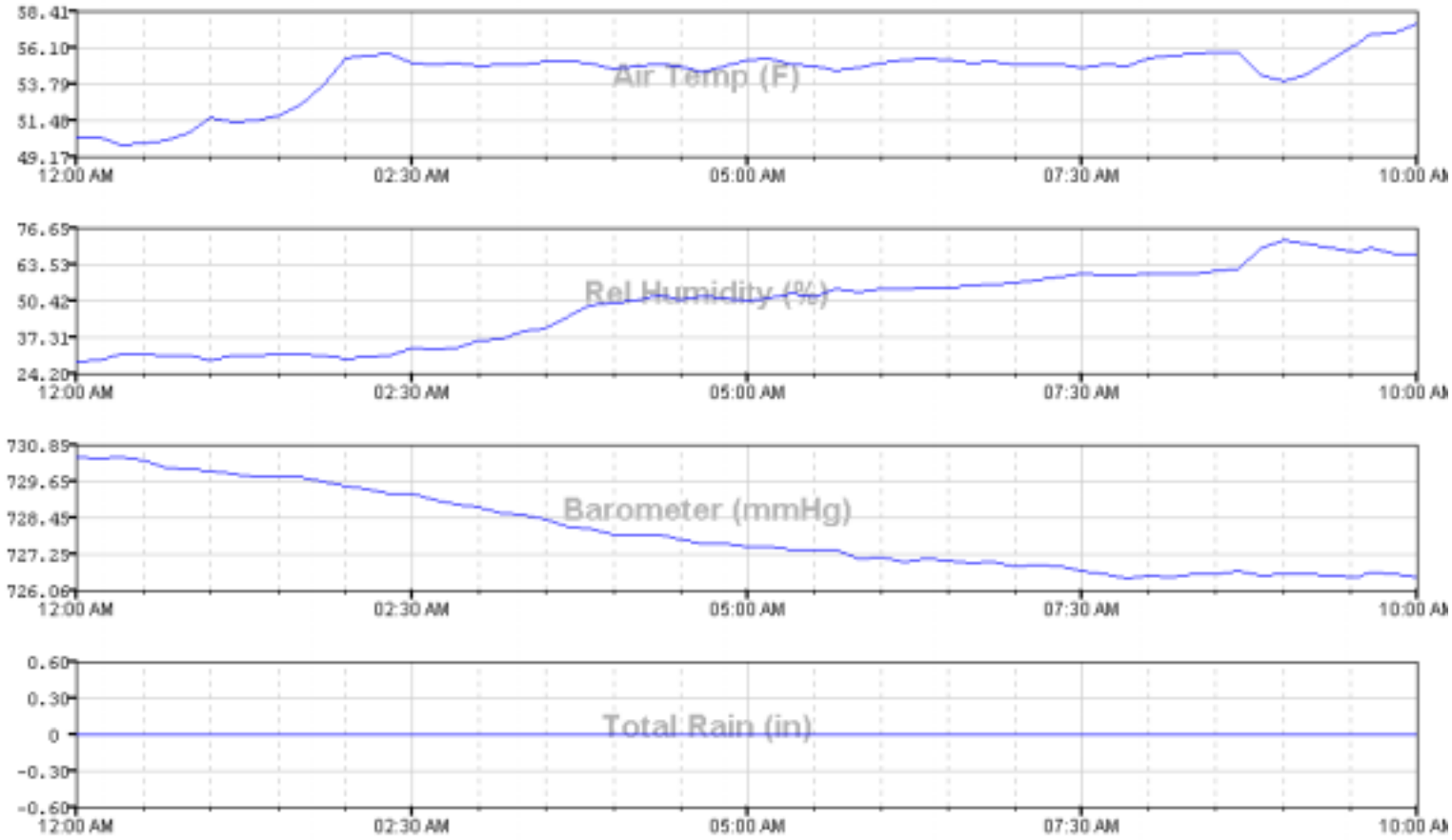
- Wind speed / direction
- Temperature / relative humidity
- Rainfall
- Solar radiation
- Barometric pressure


# Weather Station Electronics

- Smart circuit
  - RS232 interface direct to PC
  - RS485 interface for network and long cable
- Collects and stores data



# Sensor Performance



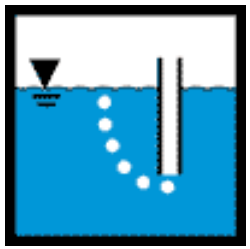
# Water Level - OTT Hydrometry

- 126 years old
- Leading supplier in Europe
- Growing fast in the US
- Level, Flow and Meteorological measurements
- Innovative designs

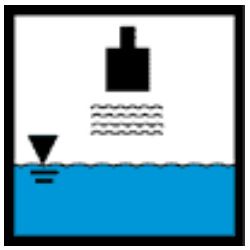
OTT
HYDROMETRIE

# OTT Products

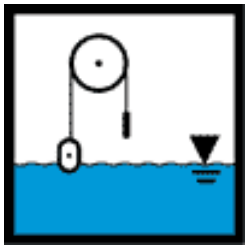
Bubbler Level Detection



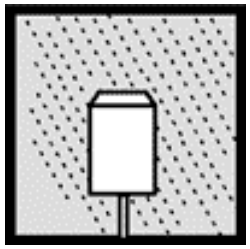
Radar Level Detection



Shaft Encoder Level Detection



Rain Gauge



# Bubbler Level Detection

## OTT - Orphimedes

- Data Logger
- 3 C batteries 12 months life
- Integrated micro-compressor
- LCD display
- Fits in a 2 inch well pipe
- Locking well cap
- Range 0 TO 32 ft
- Accuracy  +/- 0.01’ ft @ 10 ft
- Simple to deploy

# Bubbler Level Detection

## OTT - Nimbus

- Integrated micro-compressor
- SDI-12 / RS232
- Fits in customer DCP
- Range 0 TO 32 ft
- Accuracy  +/- 0.01’ ft @ 10 ft
- Log 11,200 values in EEPROM rollover memory

# Shaft Encoder Level Detection

## OTT – Thalimedes

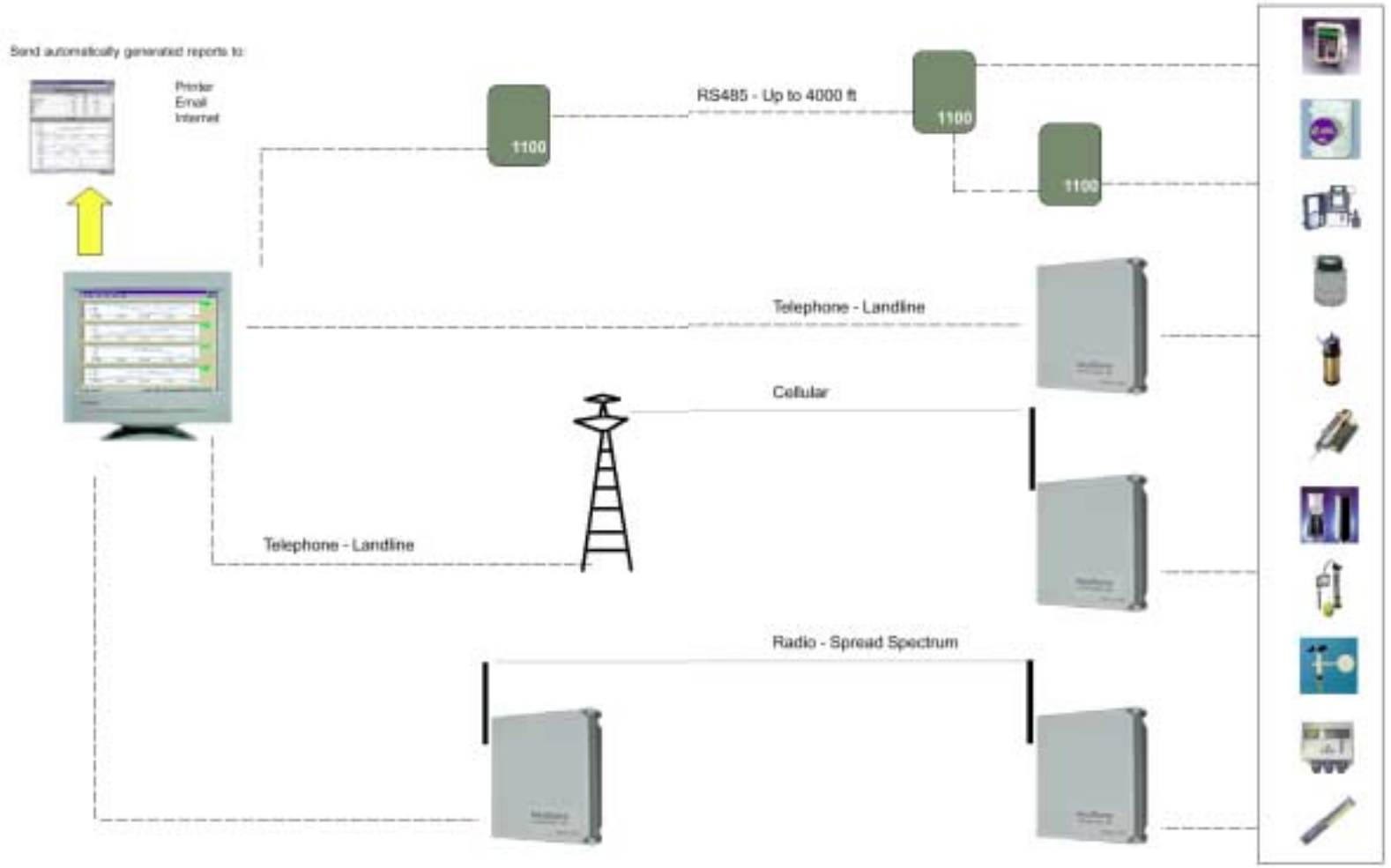
- Logging shaft encoder for surface water and ground water
- 1 C-Cell battery – 12 months
- Log 32,000 readings in EEPROM with rollover
- Wireless infrared RS232 for programming and download
- Motion activated display
- SDI-12 output

# Radar Level Detection

## OTT - Kalesto

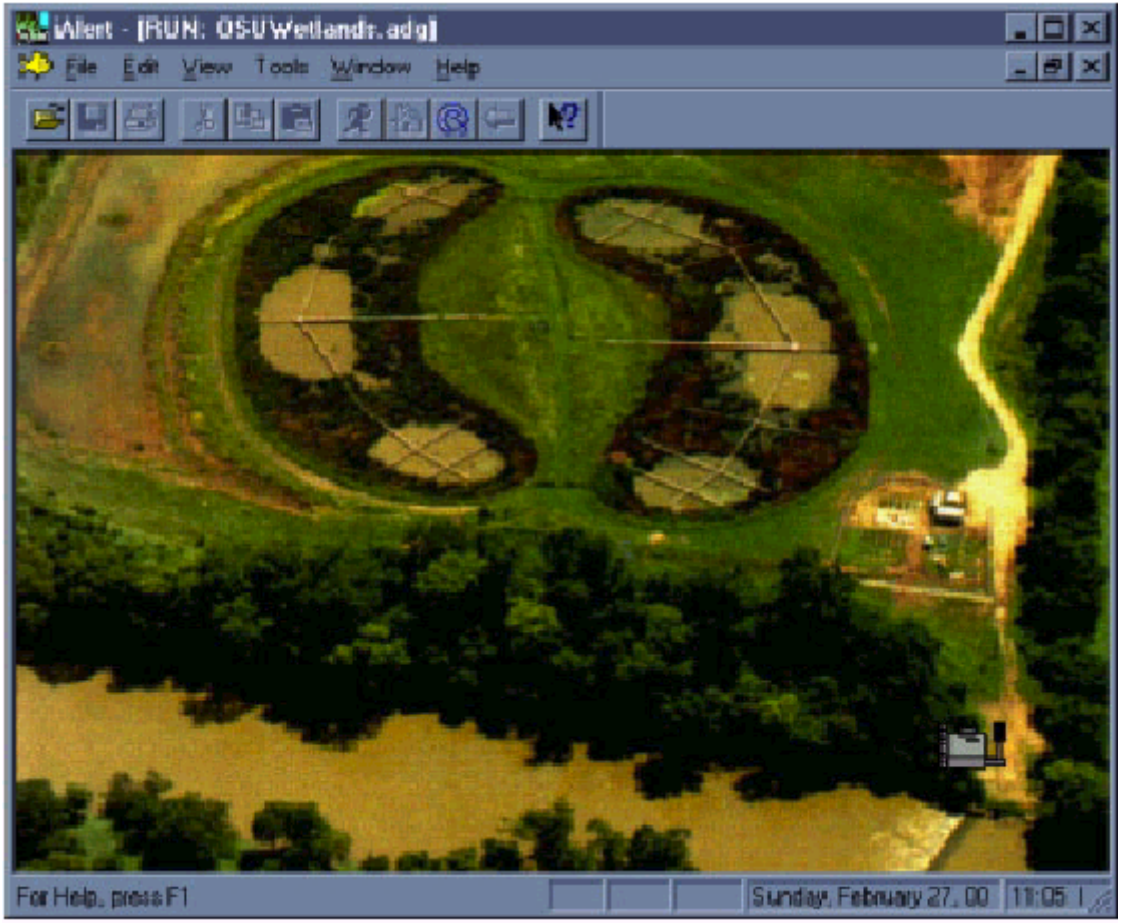
- Non contact radar technology
- No stilling well required
- Not affected by wind, fog, temperature gradients
- RS485 and SDI-12 interface
- Up to 3300 ft cable distance

# Wireless / Software - NexSens



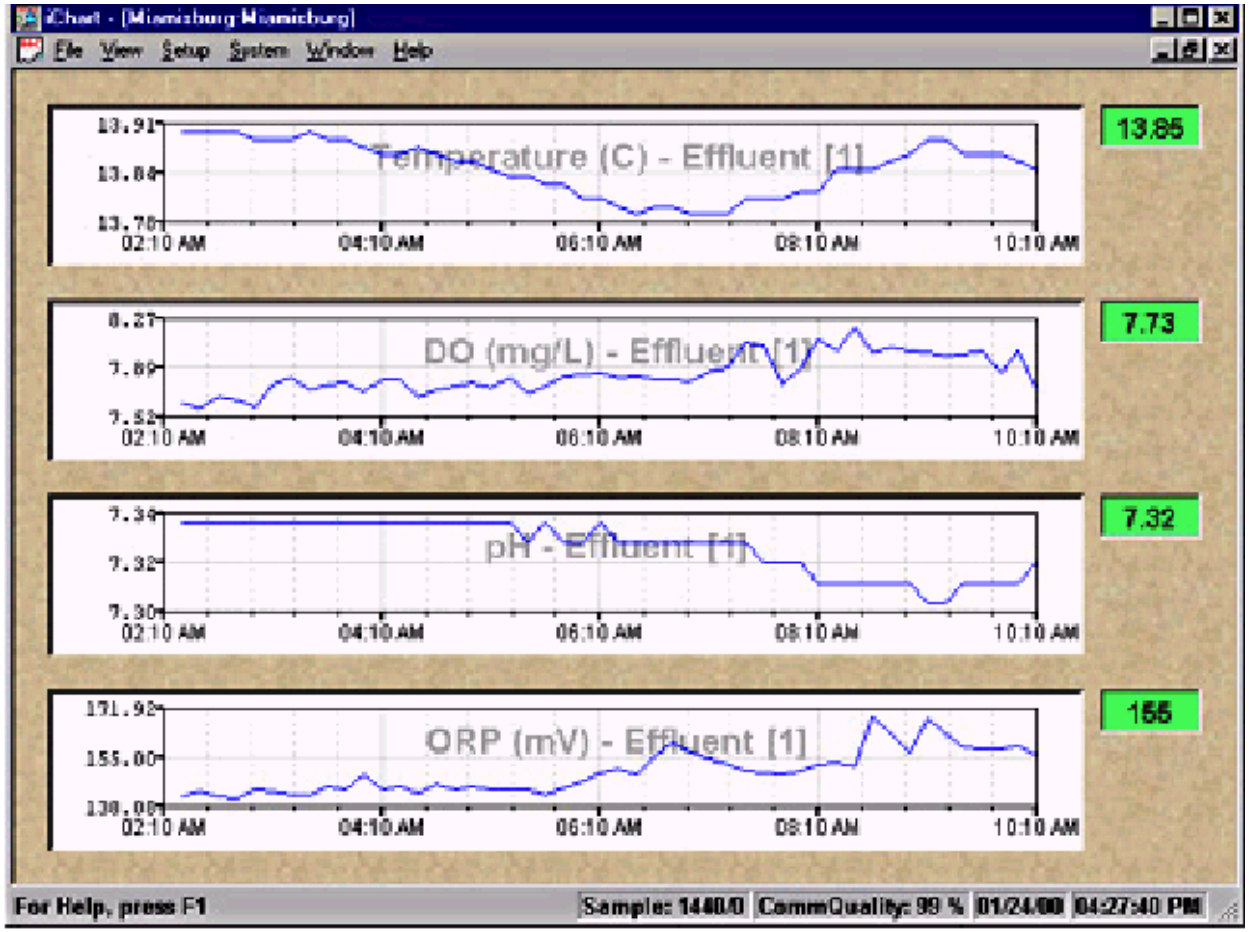
# NexSens iAlert Software

- Graphical database software
- Point and click
- Microsoft Access
- Place pre-defined components on a basemap
- Reports, statistics and plots

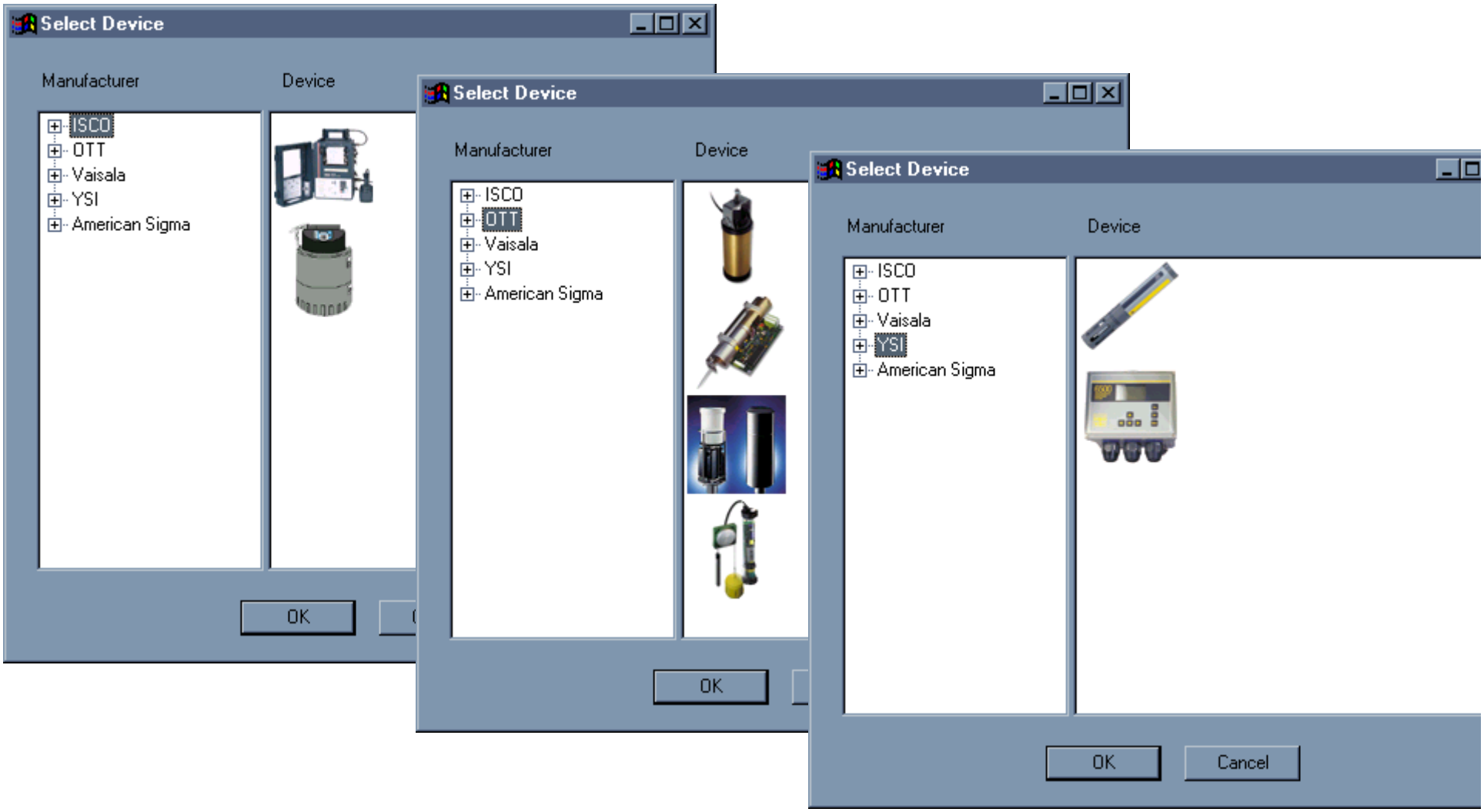


# NexSens iChart Software

- Cross platform software.
- Interface to:
  - ISCO
  - OTT
  - YSI
  - Am Sigma
  - Vaisala
  - More …



# NexSens iChart Software

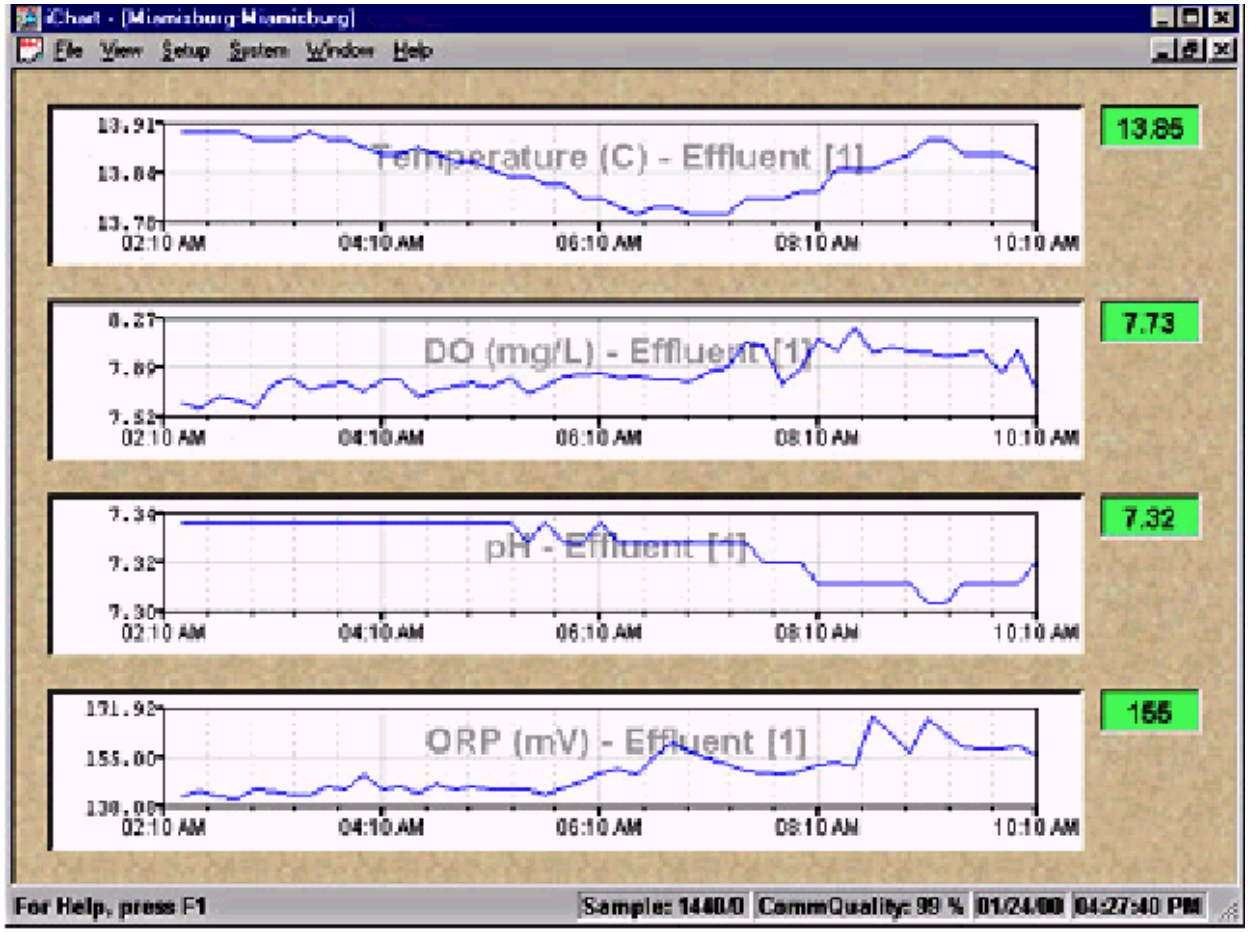


# NexSens iChart Software

- Choose communication method
  - Radio
  - Telephone
  - Cellular Phone
  - Direct RS232
  - Direct RS485
  - Direct SDI-12

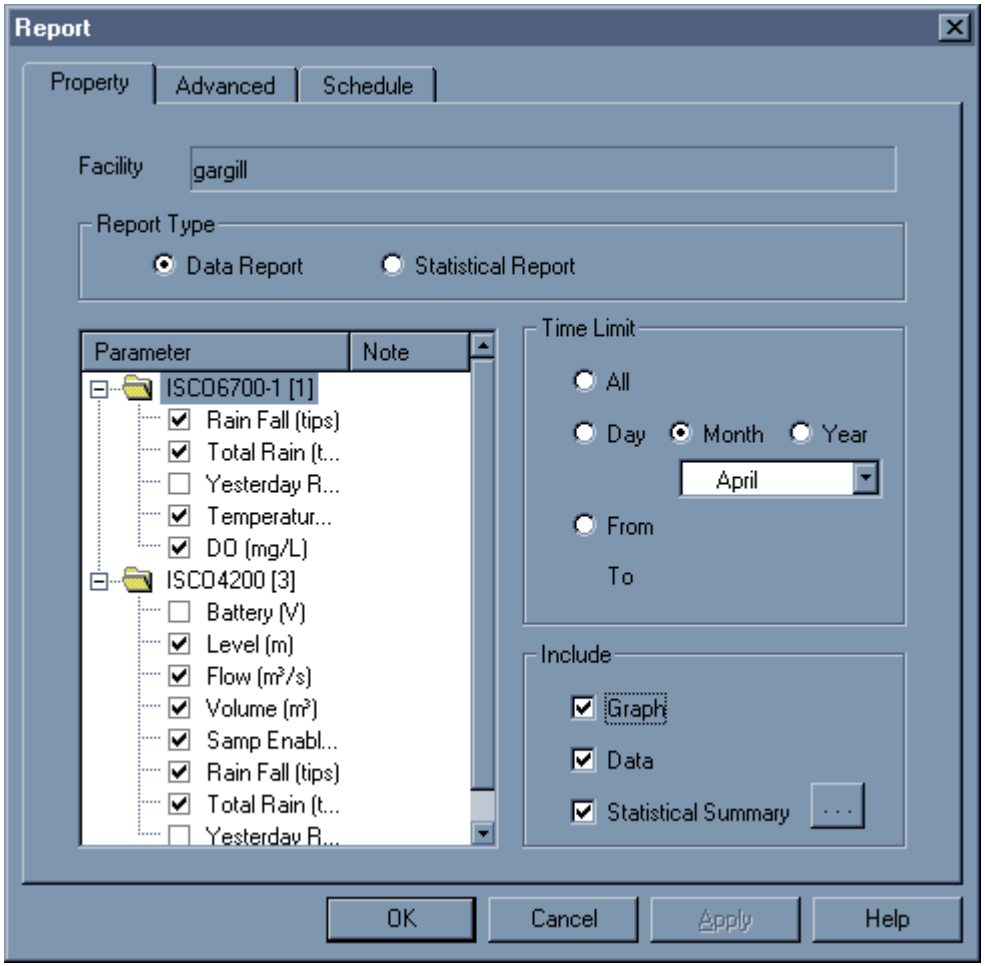
# NexSens iChart Software

- Start Charting



# NexSens iChart Software

- Query the database
- Generate report
  - Data
  - Statistics
  - Plots
- Schedule reports:
  - Printer
  - Email
  - Fax



# Data Quality

- Data Quality ➔ Better understanding of the ecosystem
  Reduced labor costs.

- Sensor Performance + Quality Assurance = Data Quality